ARRIVAL AND DEPARTURE OF WINTER CONDITIONS IN THE MACKENZIE RIVER BASIN*

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The life of the few white inhabitants of the Mackenzie Valley north of Lake Athabaska is intimately bound up with the waterways of the great river system. Interest still centers almost exclusively in fur trading. The annual export of furs from the basin as a whole is said to amount to some $2,000,000. Its transportation is dependent on the rivers. The railway ends near McMurray: from that point to the Arctic coast steamer navigation on the Mackenzie is interrupted at but one point, the rapids at Fort Smith. Two lines of steamers have for a number of years been engaged every summer in bringing out the winter catch of fur and taking in the yearly consignment of supplies to the trading ports which are located from 100 to 200 miles apart throughout the Mackenzie River system.[1]

During the winter season the only communication between the Mackenzie Valley and the outside world is maintained by dog sledges or carioles (Fig. 2) which carry the mails in and out of the Mackenzie Valley once a month. Only first-class mail, however, is carried on these.

It may well be understood that to the inhabitants the great seasonal events of the year are the opening and closing of navigation on the waterways of the basin. These are also events of interest to the geologist and geographer.

The appearance and disappearance of winter ice in the Mackenzie Valley mark the limits of the seasonal period during which the processes of erosion are active over about one quarter of the continent. As will subsequently be shown, this period is relatively short in Northwestern Canada as compared with more southerly latitudes, a circumstance which must result in a correspondingly slow degradation of the land surface.

WINTER CONDITIONS

The character of the winter temperature in Northwestern Canada is indicated in Table I, which shows the minimum temperatures (in degrees Fahrenheit) recorded in each of the winter months, 1915–1916 to 1918–1919 inclusive, at Fort Simpson, Hay River, and Edmonton.

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During two field seasons spent in the Mackenzie Valley the writer has had an opportunity to note the dates and some of the features incident to the opening and closing of navigation on the Mackenzie and its larger tributaries. On each of his trips to the Mackenzie, Great Slave Lake was entered as early as the ice would permit. The journey out in 1919 was completed after many streams and small lakes had been closed by ice.

[1] See E. J. Alcock: Past and Present Trade Routes to the Canadian Northwest, *Geogr. Rev.*, Vol. 10, 1920, pp. 57–83.

Probably no better authority for the character of the winter climate of the lower Mackenzie Valley can be cited than R. MacFarlane, who spent many years in the region. He wrote as follows of the winter conditions at Good Hope:

During the months of January and February, 1863, the thermometer was frequently as low as 50° and 60° below zero of Fahr.; it was also several times down to 65° and 66°, and once actually at 70°! Notwithstanding this fearful cold, we trip all the same. [See Fig. 2.] I was travelling myself, accompanied by six loaded sleds, on the voyage from Good Hope, during this severe cold. Last winter, however, was by no means so severe; the thermometer was comparatively seldom at 50°; it was once only at 55°, and once also 60° minus. In summer it is exceedingly hot at times.[2]

TABLE I—MINIMUM TEMPERATURES IN NORTHWESTERN CANADA[3]

STATION	SEASON	MONTH					
		Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Fort Simpson (lat. 61° 50′ N.)	1915–16	—19	—39	—45	—48	—44	— 7
	1916–17	—14	—48	—55	—62	—31	—18
	1917–18	—21	—57	—54	—45	—34	—24
	1918–19	—20	—24	—48	—55	—44	— 6
Hay River (lat. 60° 50′ N.)	1915–16	—18	—37	—51	—44	—45	— 8
	1916–17	—17	—40	—55	—55	—43	—24
	1917–18	—20	—60	—58	—50	—42	—24
	1918–19	—20	—34	—38	—56	—52	
Edmonton (lat. 53° 33 'N.)	1915–16	— 3	— 6	—45	—37	—20	—17
	1916–17	— 8	—37	—44	—50	— 8	— 7
	1917–18	—13	—42	—43	—33	—28	— 2
	1918–19	— 3	— 0	—15	—37	—32	—22

It is evident that in a region of great lakes and great rivers, where nearly every winter shows a lowest temperature of 50° F. or more below zero, a vast quantity of ice must prevent erosion and navigation for a long period.

THE SPRING BREAK-UP

The break-up of the ice in spring begins in the small streams. Joseph Keele, who spent a winter in the Mackenzie Mountains, describes it thus:

In spring, the small side streams are the first to open, then the pressure from the increase of water in the main streams arches the ice sheet and finally breaks it up. The broken ice usually jams at some point lower down, the pent-up water behind the jam breaks out again and sweeps the river clear of ice. This operation is repeated until the entire river is open, no ice being left at the margins.[4]

[2] R. MacFarlane: An Account of the Mackenzie River District, *Proc. Royal Geogr. Soc.*, Vol. 9, 1864–65, pp. 125–131; reference on pp. 129–130.

[3] Furnished to the writer by the Canadian Weather Bureau.

[4] Joseph Keefe: A Reconnaissance Across the Mackenzie Mountains on the Pelly, Ross, and Gravel Rivers, Yukon and North-West Territories, Geol. Survey Branch, Dept. of Mines Ottawa, 1910, p. 20.

The formation of ice jams often leads to rapid and destructive rises in the northern rivers. At the mouth of the Clearwater River a rise of about 30 feet, which was caused by an ice jam in the spring of 1919, resulted in the loss of a large quantity of provisions stored at McMurray. Alfred H. Harrison described the break-up as he observed it on the Slave River as follows:

> The breaking up of the ice on these rivers is a grand sight. In the spring of that same year I happened to be encamped about two miles above a bend in the Slave River: in this bend the ice, which had broken in mid-stream, got jammed, and during that night the water, in three hours, rose 14 feet. Sometimes, indeed, the ice gets piled 20 feet high in places and seems to be solidly blocked right down to the bottom of the river; for as the ponderous fragments come along, they are drawn in underneath the pack, and it is only when the water has risen in this manner that the stream at length finds outlet and rushes away with a terrific roar, sweeping away the vast wreckage in its onset; and therewith the ice has wholly passed away for the season, saving only some isolated masses that emerge many days afterwards, covered with mud, from the river bed into which they have been driven by the enormous pressure from above.[5]

A photograph[6] taken by the writer shows a remnant of one of these ice jams on the bank of the Mackenzie which had a thickness of 25 feet in the last days of July.

The ice of Great Slave Lake blocks the navigation of the Mackenzie River for nearly a month after the great river is free of ice (Figs. 3 and 4). Owing to this fact navigation on the Mackenzie is limited to about three and one-half months. The record of the ice break-up at Rae on Great Slave Lake entered in the Hudson's Bay Company journals and published by Russell[7] shows the break-up during 6 years (1857–1859 and 1883–1885) to have ranged from May 30 to June 23. The general direction of the wind in spring, however, drives the ice toward the southern shore so that steamers seldom venture into the lake before the first of July. The photograph (Fig. 4) shows the character of the Great Slave Lake ice encountered by the writer late in June, 1917. Ice floes were present on the southern shore of the lake up to June 30 in 1917. In 1919 the writer passed through Great Slave Lake the last week in June without seeing any ice. Mr. Vail of Hay River reported that the ice disappeared in 1919 about June 15, an unusually early date.

The Mackenzie at Simpson, which is near latitude 62°, opens from May 4 to May 20, averaging from the 10th to the 15th, according to Captain Mills, who has spent several years at Simpson and has run steamers on all of the navigable waters of the Mackenzie basin. Because of nearly dead water in the Mackenzie for a long distance, the head of the river opens two and a half or three weeks later than at Simpson. The opening of Great Slave Lake generally occurs, according to Captain Mills, between June 16 and July 2, or six weeks later than the Mackenzie below Simpson.

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[5] A. H. Harrison: In Search of a Polar Continent, 1905-1907, London, 1908, pp. 17–18.

[6] E. M. Kindle: Notes on Sedimentation in the Mackenzie River Basin, *Journ. of Geol.*, Vol. 26, 1918, pp. 341–360; reference on p. 355.

[7] Frank Russell: Explorations in the Far North, Univ. of Iowa, Iowa City, 1898, p. 86.

McConnell states that the Liard ice broke into the Mackenzie May 13 in 1888. This is nearly six weeks before the ice in Great Slave Lake will permit steamers to reach the Mackenzie. The Liard, which is the largest tributary of the Mackenzie, breaks up before the Mackenzie and opens that stream below its mouth while the upper part of the Mackenzie is still

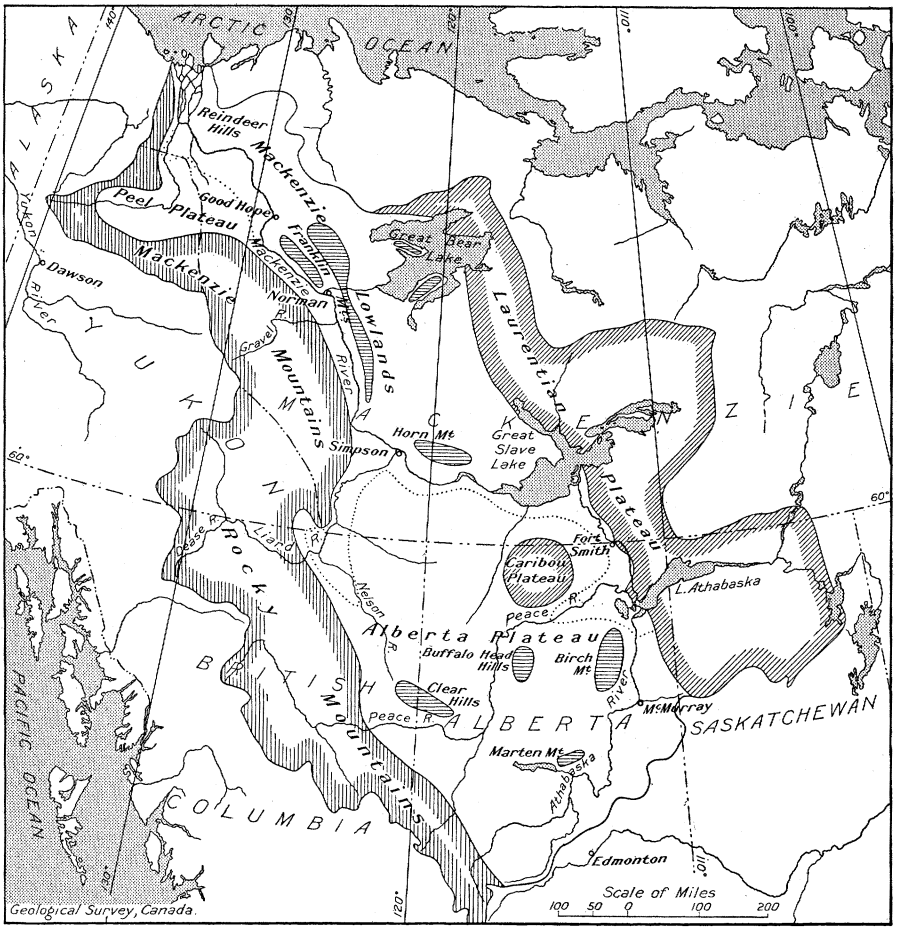

FIG. 1—Diagrammatic map of the physiography of the Mackenzie River basin. (After Camsell and Malcolm: The Mackenzie River Basin, *Geol. Survey of Canada Memoir* 108, 1919.)

covered with ice. The sudden rush of the Liard waters and broken ice across and through the deeply frozen surface of the Mackenzie is a spectacular feature of the break-up at Simpson. The jammed ice frequently piles high above the Hudson's Bay Company's stockade at Simpson before the firm ice of the main stream gives way and lets the Liard waters crash a channel across the Mackenzie. McConnell gives the following account of the Liard breaking into the Mackenzie:

At midnight the dam at the mouth of the Liard gave way, and the massive crystal structure was hurled by the liquid energy behind it against the firm ice in front with such force that the whole sheet, for some miles below the fort, was crushed into fragments by the impetuosity of the assault.[8]

The appearance of the ice encountered on the river bank after the jam has given way and the water fallen, is shown in Figure 5. The moving mass of ice set free by the break-up is shown in Figure 6. There is scarcely a mile of the river banks that does not show traces of the destructive work done by these great blocks as they travel seaward. In some places the spruce trees at the top of the banks have been snapped off like straws;

FIG. 2—Winter travel on the Athabaska River.

in others the clay banks have the appearance of having been plowed by titanic plows. In late summer the gravel bars about the mouths of tributary streams often show numerous grooves cut by the shoving of grounded ice blocks.

The Nelson River, which is the largest southern branch of the Liard, breaks up, it is said, as early as the main stream which, as stated above, opens the Mackenzie below Simpson more than a month before steamers can get through the ice on Great Slave Lake. The Nelson is large enough for navigation by small steamers as far as Fort Nelson, 100 miles above its mouth, and for flat boats still farther south. The construction of a wagon trail or railway from St. John on the Peace to the upper part of the Nelson River, a distance of about 175 miles, would give access to the Mackenzie River more than a month earlier than is now possible, owing to the late opening of Great Slave Lake. The success of the first oil well ever drilled

[8] R. G. McConnell: Report on an Exploration in the Yukon and Mackenzie Basins, N. W.T., *Ann. Rept. Geol. Survey of Canada*, Vol. 4 (N. S.), 1888–89, pp. 1 D–163 D; reference on p. 87 D.

in the Mackenzie Valley in getting oil during the past season may eventually lead to the serious consideration of this entirely feasible method of lengthening the navigation season of the Mackenzie by one month.

McConnell, the pioneer geologist in the Mackenzie Valley, spent the early spring of 1888 at the mouth of the Liard. His graphic description of early spring conditions follows:

> The warm weather which commenced on the 1st of May continued throughout the month, and under its influence the snow quickly disappeared, and the spring advanced with astonishing rapidity. On the 20th of April, the first day the temperature rose above freezing point for nearly six months, the barking crow (*Corvus americanus*) made its appearance.

FIG. 3—Fishing through the ice on Great Slave Lake.

> The raven (*Corvus corax*) had remained throughout the winter. On the 1st of May some Canada geese (*Branta canadensis*) were seen at the edge of an open place in the river, accompanied by a flock of mergansers and other ducks. The 4th brought the robin (*Turdus migratorius*) and some sparrows, and on the 5th the wavies (*Anser hyperboreus*) which usually lag a few days in the rear of the Canada geese, commenced to wing their way northwards and in a couple of days were passing in such numbers that flocks were rarely out of sight.[9]

In speaking of the western tributaries of the Mackenzie River in a region some 400 miles north of the mouth of the Liard, Keele[10] states that the rivers open between May 10 and May 20 and flood water comes down early in June.

MIDSUMMER CONDITIONS

All traces of winter conditions have disappeared from the Mackenzie Valley by the time the first steamer is able to get through Great Slave Lake to the head of the river, which is usually early in July. Concerning the

[9] McConnell, p. 86 D.
[10] *Op. cit.*, p. 23.

climate of early summer Keele, who wintered near the head of the Gravel River, remarks that "June is a perfect summer month with practically no darkness and on fair days nearly twenty hours of bright sunshine; the temperature sometimes reaches as high as 90°."[11] The nearly continuous sunshine of June is the great factor in the exceedingly rapid development of vegetation. "Compared with Ottawa, Simpson has an average of three hours more sunlight daily for the summer months, which means about eighteen days of additional sunshine during the three months when sunshine is most important."[12]

FIG. 4—The last stage of winter ice on Great Slave Lake. (Photograph taken June 28, 1917.)

The traveler in the Mackenzie Valley who sees for the first time the limestone scarps and cliffs of the Mackenzie Mountains so near the Arctic Zone entirely free of snow in midsummer, is apt to be surprised when he recalls the glaciers and permanent snow fields which are familiar features of the same mountains many hundreds of miles farther south. The Nahanni Mountains of the Mackenzie Valley, which are quite free of snow in July, are in about the same latitude as the mouth of Frobisher Bay, Baffin Land, where the writer has seen a ship stuck for days in the ice floes and experienced a snow storm late in July. The warm genial summer climate of the Mackenzie Valley cannot fail to impress anyone who is familiar with the bleak coasts of northeastern America which lie in the same latitude. Although the middle portion of the Mackenzie Valley lies in about the same latitude as Baffin Land, its summer climate bears a much stronger resemblance to that of the Gaspé Peninsula in the Gulf of St. Lawrence than it does to the Baffin Land summer. Camsell, who has a more intimate knowledge of the climate of the Mackenzie Valley as a whole than anyone else

[11] *Op. cit.*, p. 22.

[12] Charles Camsell and Wyatt Malcolm: The Mackenzie River Basin, *Geol. Survey of Canada Memoir 108; Geol. Ser. No. 92*, Ottawa, 1919, p. 43.

who has written on the subject, states that "in general it may be said that any point in the Mackenzie basin has a milder climate than any corresponding point of the same latitude in northern Manitoba, Ontario, or Quebec."[13] The relatively warm summer climate of the Mackenzie Valley may be ascribed chiefly to its remoteness from the chilling influence of Hudson Bay and to its low average elevation. Most of this great lowland is less than 500 feet above sea level, while much of the northern half of Alberta immediately south of it lies 2,000 or more above tide. Warm air currents from the Pacific may also be a factor.

FIG. 5—Stranded silt-covered ice left on the bank after the Liard has broken across the Mackenzie. (Photograph by Captain Mills.)

Many varieties of flowers in bloom crowd the fire-cleared spaces of the lowland and the mountain slopes early in July. Among these, two species of orchids occur locally in abundance. Ripe red raspberries were seen on August 7 at Bear Mountain, which is about 80 miles south of the Arctic Circle. Blueberries were a feature of the writer's camp fare from the first week in August to the end of the summer. The wild strawberry is abundant along the Mackenzie as far north as Simpson, at the mouth of the Liard, which appears to be near the northern limit of its range. No trace of it was seen north of Simpson, and inquiry failed to elicit any evidence of its having been seen by others farther north.

The gardens of the agents of the trading companies which may be seen at intervals of 150 to 200 miles along the Mackenzie show that excellent crops of all the more hardy garden vegetables may be grown in favorable seasons as far north as the Arctic Circle. Potatoes which the writer selected from a field at Simpson weighed in two or three cases a few ounces over a pound each. A turnip—the largest of a lot purchased for camp use from an Indian garden at Simpson—had a length of nine inches and a diameter

[13] *Op. cit.*, p. 43.

of five inches, the long tap root not being included in these figures. Oats and barley are raised at Simpson, though ripening is uncertain, and a few cattle are kept there on the Government farm. There is however, always the possibility of an August or July frost destroying the vegetables which in favorable seasons compare well with those raised in southern Canada.

Thawing in the upper part of the Mackenzie Valley proceeds downward a few feet below the surface in summer. Mr. Harris, who is in charge of the Government farm at Simpson, states that his well entered frozen ground at a depth of about 5 feet and passed out of frost at about 40 feet. A frost limit of 40 feet is in sharp contrast with the conditions prevailing in the Yukon valley and the Nome district in Alaska. Near Nome a shaft 120 feet deep did not penetrate below perpetual frost. Cleveland Abbe states that "there is only one instance on record where excavation in this northwestern region has gone below the zone of perpetual frost."[14] This is a Klondike shaft which passed through the frost zone into flowing water at about 220 feet.[15] The relatively moderate depth of frost penetration in the upper Mackenzie Valley as compared with the lower limit of frost in the Klondike and much of northern Alaska clearly indicates a less rigorous climate.

Autumn Conditions

The writer spent the latter part of August and the first ten days in September in the Wrigley district. At river level the first frost came here on September 1. Snow made its first temporary appearance on the summits of the mountains east of Wrigley (latitude 63° N.) on August 21. After September 7 the summit of Cap Mountain above 4,400 feet was permanently snow-covered. We left Wrigley for Simpson on September 10. In tracking up the Mackenzie and the lower Liard from Wrigley we found the somber dark green of the landscape enlivened by the bright yellow of the numerous patches of poplar which break the otherwise continuous spruce forests. This is the ideal part of the year in the Mackenzie Valley. The mosquito pest, which greatly abates late in August, disappears altogether with the first frost. One can then discard one's protective head net and canvas gloves, which earlier are absolutely essential to comfort if not existence, and sleep comfortably in the open when making short trips inland from the river.

Nearly perfect weather for outdoor work prevailed during most of the month of September. Wild gooseberries in good condition and four species of plants in bloom were seen at Simpson on September 28, the date of our departure for the "outside," as all railway-served lands are called in the north.

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[14] A. H. Brooks: The Geography and Geology of Alaska, A Summary of Existing Knowledge; with a Section on Climate, by Cleveland Abbe, Jr., *U. S. Geol. Survey Professional Paper No. 45*, Washington, D. C., 1906, p. 147.

[15] J. B. Tyrrell: A Peculiar Artesian Well in the Klondike, *Engineering and Mining Journ.*, Vol. 75, 1903, p. 188.

The Coming of Winter

At Simpson the first notable freeze of the season of 1919 occurred on the night of September 25. Thin ice on quiet pools and a crust on wet ground were noted on the 26th. The first strong hint of the approach of winter was encountered at Providence, 50 miles below the head of the Mackenzie (latitude 61° 25′ N.) At that point the writer found two or three inches of snow covering his blankets on waking October 1. At the head of the Mackenzie River in Wrigley harbor we found Mr. Camsell, Hudson's Bay Company factor at Simpson, with the Steamer *Liard River*, which had towed half a dozen Indian scows up to the lake where the main winter supply of

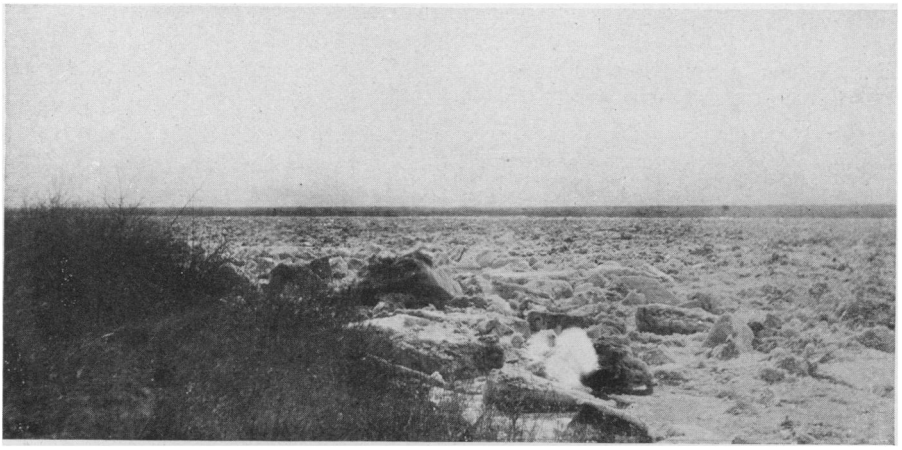

Fig. 6—Ice moving down the Mackenzie at Norman.

fish for men and dogs is caught late in September and early in October. Fishing, however, does not cease with the coming of ice, as may be seen from the photograph, Figure 3. It was still too early for ice to form on Great Slave Lake when we crossed it early in October. According to Hudson's Bay Company journals kept at Rae on Great Slave Lake, the earliest closing of the lake recorded there is October 6, 1864. In 1857 ice closed the lake on October 19, and in 1880 on October 28.[16] Ordinarily the upper Mackenzie is closed to canoe navigation by running ice about the middle of October. Mr. Blow, a missionary, informed the writer that in 1918 the Mackenzie first froze over at Norman on November 6. It broke and finally froze solid on November 11. A. H. Harrison[17] found the lower Mackenzie still open at Arctic Red River on October 4 in 1905 although he had encountered floating ice several days earlier.

A light snow covered the entire landscape when the launch carrying the writer's party arrived at the foot of Smith Rapids on October 4. This

[16] Russell, *Op. cit.*, p. 86.
[17] Harrison, *Op. cit.*, p. 28.

snow remained during the four days spent in portaging the 16 miles of rapids and getting started again on the upper Slave, and snow-covered river banks were a feature of the landscape during the remainder of the journey.

The freeze-up of the Slave was not yet due for two weeks according to those familiar with the river, but the low temperature, snow, and frozen ground strongly suggested its imminence at the time of our departure from Fitzgerald at the head of the Smith Rapids. Thin cakes of floating ice, which were encountered constantly after leaving this point, became steadily more numerous and thicker. On reaching the mouth of the Peace an attempt to avoid a rapid in the Slave by going through the delta of the Peace via the Quatre Fourches Channel failed because solid ice had entirely closed this relatively sluggish channel. We were forced to retrace our way back to the swifter main channel of the Rocher River leading to Lake Athabaska. Much ice was encountered in the very shallow western arm of the lake. The ice conditions met with from near the head of the Slave to the mouth of the Clearwater are indicated in the following excerpt from the writer's notes:

Oct. 9. Turned back by ice in the Quatre Fourches Channel in afternoon. Ice 1 inch thick. Where broken up and overslid, 2 to 4 inches thick.

Oct. 10. Met constant floes of fresh pan ice in upper part of Rocher River.

At Chipewyan (on Lake Athabaska) the protected bays have about 1 inch of ice over them, but no ice in the wind-swept water.

In shallow western end of lake ice is abundant except in the main current of the river.

Oct. 12. Much ice in middle of river in A. M. 1/8 inch thick, but in floating sheets. Quite cold during last night.

Oct. 13. Reached McKay (50 miles below McMurray) in A. M. where we abandoned the scow, which was nearly cut through by ice, transferring baggage to two skiffs. One skiff was broken through by ice and set adrift in afternoon. Reached the steamboat cache at night. River nearly covered by floating ice pans of all sizes up to 60 feet across, but all moving.

The current and contact of the ice pans tends to give them a rotary motion, tending to round off the corners and make circular pans.

Oct. 14. Started on foot for McMurray (16 miles) this A. M. after sleeping in the open under a spruce tree very comfortably. Launch was beached, repaired, and followed with baggage.

Small streams and channels of river with no current frozen over solid with smooth ice.

Big pans of ice five or six inches thick moving freely in current but extending nearly across the river. These floating pans, though thick, are mushy; but where there is no current, hard ice 1 to 2 inches thick.

Reached bank of Clearwater about 4.30 P. M. Crossed in canoe in thick floating ice to McMurray.

The southern channel of the Clearwater at McMurray we found frozen solid enough to permit of crossing on foot.

The nearly continuous sheet of moving ice in the Clearwater made navigation impossible about 18 miles from McMurray, so that the last 35 miles of the journey back to the railroad was accomplished on foot.

People residing at McMurray assured the writer that the freeze-up in 1919 came several days earlier than usual. But that it was not without precedent is shown by Hanbury's experience some 18 years ago. He was frozen in at McKay (where we abandoned the scow) on October 15 and resumed his journey a month later with dogs.[18] Information from various sources indicates, however, that in 1919 winter began at an unusually early date. The freeze-up came equally early on the Yukon River. The newspapers, under date of October 15, reported two steamers delayed and one frozen in north of Dawson. D'Arcy Arden, who shares with another man the distinction of representing the only white inhabitants of the immense region comprising the basin of Great Bear Lake, writes as follows concerning the early arrival of winter on Great Bear Lake in 1919:

> I was frozen in on October 4 at Cape McDonnell, Great Bear Lake, after being in the worst storm I have ever seen, lasting five days. I lost both my anchors and every foot of line I had and landed up on a sandy beach on a small island eighty miles from home.[19]

The early appearance of winter conditions did not yield, in 1919, to temporary milder weather. Snow and frozen ground were encountered all the way from Fort Smith to Edmonton where the temperature on October 25 was reported to be 15° below zero. In traveling eastward a continuous sheet of snow was found late in October as far as western Ontario.

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[18] D. T. Hanbury: Sport and Travel in the Northland of Canada, London, 1904, p. 253.

[19] Letter of August 10, 1920.